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Bedbug Education, Treatment, and Prevention

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Abstract

Cimex lectularius (bedbug) has become a severe issue in more recent years due to travel, immigration, and importation of products. Unfortunately, most people do not know their biology hence do not treat these arthropods correctly. Many myths and misinformation are currently available to people on the internet and with pest professionals. Education and proper treatment must eradicate these pests in homes, commercial buildings, and other places. To prove whether or not education with treatment garners better results, ten homes were treated with the same heating and chemical process, with only five being educated before, during and after. All homes were inspected for bedbugs and infestation size, reentry risk, and finally, the number of bedbugs found at each follow up were recorded. It has been shown through the data collected that houses treated had education on bedbugs and an IPM plan for after treatment had far fewer instances of bedbugs on returning visits.

Introduction

The basis of this study is to show that with client education and proper treatment protocols, eradication is possible and reduces re-infestation risks. The client needs to be educated on the biology of bedbugs, how they potentially entered the home, and how to minimize reintroduction of future infestations. Most people honestly believe that *Cimex lectularius* is an insect of the poor and unclean, which is not valid. Anyone can accumulate a bedbug infestation just by doing day-to-day things; however, some individuals are more high risk than others due to their careers or modes of transportation, and so on. We will be conducting heat treatments in a total of ten homes with and without client education, risk assessment, and post-treatment protocols. The outcomes of this study should show that education and a post IPM plan are crucial in eradicating and reintroducing these insects, thus reducing future treatments with excessive chemical applications.

Bedbug Life Cycle and Biology

Bedbugs are a parasite to mainly humans, feeding on our blood for survival. Each bedbug feeding takes anywhere from five to ten minutes for the bedbug to become satiated (CDC, 2015). There are five nymphal stages before *Cimex lectularius* becomes a sexually reproducing adult. Each nymphal stage requires a blood meal in which the arthropod will molt to the next step of life (CDC, 2015). *Cimex lectularius* has been known to carry diseases like Q-fever, Hepatitis, Oriental Sore, Leprosy (University of Florida, 2017), and Chagas in new studies.

Eggs are white to opaque in color and difficult to see with the naked eye and are 1mm in length, hatch after ten days, and are attached to surfaces. The amount of time it takes for an egg to hatch determines the length between follow-up visits after the initial heat treatment. Female

bed bugs can lay up to 200 to 250 eggs in her lifetime, equating to roughly five eggs a day in sheltered areas (CDC, 2015). As a result, adults look pretty different after having a blood meal versus before seeking a host. A fully engorged bedbug is much more significant in size and appearance, having a more oval shape and substantially darker in color. In contrast, an unfed adult is more rounded in shape and light brown, possibly noticeably darker brown spots on the abdomen where it is still digesting the last blood meal.

Industry Standard Treating Options

The standard for treating bedbugs varies; however, there are some underlying commonalities. Mainly companies treat bedbugs with various chemical applications, some only once and others over a set period. When treatments are performed, the client is never educated on the insect at all. There is no communication on biology or possible ways the resident has managed to obtain an infestation. Chemical application is mainly accomplished by over saturating belongings, baseboards, and other items to eradicate the bedbugs. The philosophy is "soaker' down and get'er done"! Why? Because it is cheaper for the company and the consumer. Full on heat treatments are expensive versus just "hosing" a place down in chemicals and crossing your fingers. Therefore, it becomes a lot easier and more profitable for companies not to invest in the equipment and buy cheap chemicals to spray all over the residence literally (this has been observed more times than one would like to admit).

A lot of companies will also have the resident remove all clothing, wash it at a laundry mat, and throw out furniture. The thinking behind having a client launder off-site and remove (throw away) furniture is that this helps in eliminating an infestation. However, as our experience and other studies from other reputable places have shown, removing items from homes can make

the infestation more difficult to control. Maybe this is another reason why they use so many chemicals during a treatment?

Why Heat?

Why use heat to eliminate bedbug infestations? Well, the answer is somewhat simple, it is effective! Not only is it effective, but there is far less chemical usage when performing a heat treatment. Treatments utilizing heat above 125 degrees Fahrenheit will kill bedbugs of all stages of life, whereas chemical treatments generally do not affect the eggs. In addition, using heat as the primary form of treatment for bedbugs allows for precisely placed chemicals and their amounts needed to become a supplement tool in the heat process.

How Heat Affects *Cimex lectularius*

Heat has been shown to be a very effective way to treat bedbugs with minimal chemical usage if any at all. It takes a lot of experience and practice to hone the exact combination and combat variables presented at each home. The eradication can be achieved with the information gained, which should be passed to others without any shortcuts or alterations to the process unless there is field-proven data to suggest alterations would be beneficial. It also takes cooperation from residents to achieve eradication which is why a lot of education is needed before, during, and after each application.

Cimex lectularius adults generally require a minimum of 118.94 °F held for roughly 95 minutes to be lethal, while eggs require a higher temperature of 130.64 °F sustained for 71 minutes to be eliminated (Kells, S. A., and M. J. Goblirsch. 2011.). While this assessment seems fair in a clinical environment, field experience has taught that there is a bit of discrepancy with

temperatures and the times needed to be lethal. Holding a room at a minimum of 125°F for a MINIMUM of 5-8 hours depending on infestation size is much more efficient at eradicating infestations which are referenced in future paragraphs.

When heat is introduced, bedbugs will hold position; however, as heat temperature rises, they begin to move to more suitable environments that are cooler. As a result, adults and nymphs alike are seen fleeing their harborage and crawling across the floor and up walls.

Heating Process

The heat treatments consisted of a unit that uses propane to heat the air, which is then forced through 12' and 16' ducts throughout the home (here is a link to the thermal setup: <https://www.facebook.com/A1HomePestControl/videos/915172449303698>)—concentrating the ducts in the areas where bedbug activity was heaviest. The entire structure is brought up to at least 125 °F before treatment is officially marked as started. Temperature readings are taken every 15 minutes in random areas of each room (fig. 1). When the unit is brought to the correct temperature, it was then held for a minimum of five hours, depending on the unit size.



Figure 1. Temperature monitored during heat treatment. Photo credit A1 Home Pest Control

While the home is coming up to temperature, the technician installed slipcovers on mattresses and box springs, dusted outlets with Cimexa dust (active ingredient: 100% Amorphous Silica Gel), treating bed frames and other pertinent areas with a mix of Temprid (Imidacloprid - 21.00%, Beta-Cyfluthrin - 10.50%) at .8ml/gal. (per label) and Cimexa was added to the solution at adjusted rates (slowly) to allow adequate spraying (Cimexa can clog sprayer and filters, slowly adding and checking sprayer provides for its use and effectiveness). These applications are essential to have in place before ideal temperatures are reached. As the temperatures rise and the bedbugs begin to move, the baseboards need to have a chemical application that will help those seeking other areas of cooler temperatures. Having the dust placed in outlets is another form of defense against the traveling arthropods. The slipcovers are best applied also before the treatment begins as the technicians tend to be very tired and worn down by the heat at the end of the treatment (with good reason). While the home is held at the required minimum temperature, anything removed that was deemed unable to withstand treatment is hand inspected by the specialist. We have also found that it is best to have any beds with wooden frames broken down entirely during the treatment process. If a wooden bed frame is not dismantled, the bedbugs will hide in the cracks, crevices, and wood joints and survive the treatment. With experience doing these bedbug treatments, we know that metal frames are beneficial to us by retaining heat significantly in the heating process, killing the insects (or forcing them to flee out in the open). For the mentioned reason above, metal frames are our preferred bed frame to recommend clients instead of wood.

Material and Methods

In this project, ten homes have been treated with a heat injection system, Cimexa dust in outlets, and the affected rooms with a mix of Temprid and Cimexa dust applied to baseboards and bed frames underneath couches/cushioned chairs. The homes were chosen by design; we selected the homes we knew would not be able to have client education, such as vacation homes or vacant rental units. The houses that were given the instruction with the treatment were selected at random. There were no parameters on infestation size, structure size, clean or dirty it did not matter. Homes that received an education with the treatment did not know they were in a study as the treatment is our standard protocol to ALL bedbug clients except those noted above (vacation rentals and so on).

Before treatment can begin, the a/c will be turned off and heat-sensitive items removed such as prescriptions, cosmetics, ammunition, candles, and anything that has the potential to melt or warp. The things taken out before the treatment are quarantined and inspected by the technician by hand and chemically treated if needed. The procedure is done on all ten homes regardless of education of the bedbugs prior—also, all homes to have Clean Brands mattress and box spring slipcovers installed by the technician. Clean Brands provide slipcovers that can withstand a heat treatment and come with a warranty and is the preferred brand for those reasons. Every home is reminded to keep the slipcovers on for at least a year, and if a tear or hole pops up, the client is to duct tape the hole until another slipcover can be placed over the existing one.

There are pre-protocols (as mentioned above) and post-treatment protocols the resident and technician must complete on all the homes that will be treated. Post protocols entail cooling the unit by opening windows to allow oxygen in and carbon monoxide to escape. With heat treatments, carbon monoxide is high, and there are protocols for the technicians to keep from being poisoned. After the windows are open, the technician will contact the residents to tell them

when they can reenter and keep windows open to allow air into the unit. At this time, we also advise against turning on the air conditioner (the temperature is too high in the unit and will burn out the a/c) and being mindful when touching metal objects that they may be hot to the touch and floors having the potential to be slippery. We also implemented a technician pre and post-treatment checklist which is listed here:

Bed bug technician check list

Updated 6/2021[Date]

- Make sure clients follow protocol:
 - The client changed into clothes from the dryer.
 - They do not leave with any purse, bags, luggage, blankets, pillows, etc.
 - The client is to take wallet and keys ONLY (of course any money, credit cards); this is to eliminate as much re-infestation as possible. Client will not be happy if they don't get rid of them. A minor inconvenience now to stop a significant inconvenience later.
 - Candles wax-based products and prescriptions are collected by the client and set at entry way while the technician sets up heat unit. When heat trailer is empty technician will gather client's items by the door and place them in the bin in trailer to be inspected for bed bugs (inspection is done at a later time). While client is collecting items, remove face plates on outlets and light switches in the bedrooms and living room (at least two on each wall of).
 - Keys left for any vehicle that remains at the structure.
- After heat treatment machine is going and belongings put in trailer, set up Nuvan sticks in vehicles (one in trunk, one in vehicle) to be left for at least two hours (this only applies to winter months, if it is summer, we skip this step but ensure windows are up on vehicles to maximize heat). The vehicle will then need to air out for two hours, leaving the trunk and windows open.
- Remember to move furniture around, especially piles of clothes; bed separated, cushions off couch throughout treatment.
- Continually check temperatures throughout treatment and adjust accordingly.
- Open window and doors to air out when treatment is done, pack up heat unit.
- After the unit is packed, dust into the outlets, you opened and apply chemical barrier in each bedroom and living room.
- When that is complete call client to let them know that windows are open, and it will be safe to return in 1-2 hours to fully reduce Co2 poisoning and chemical settling.

On the five homes educated on bedbugs and provided an IPM program in which there is a lot of explaining, one-on-one talking, and making sure the client understands all the aspects of the insect and the treatment. The one-on-one is usually lengthy talks with an administrator in the bedbug department and the bedbug specialty technician again before the treatment occurs. When having these discussions, the client understands that the pests came from somewhere (try to pinpoint when it started and go from there), their biology, risk level, and then a plan for post IPM to keep reintroduction low. In the process of educating the client, they are given a to-do list which is included below:

Prep for Bed Bug Thermal Treatment – Before we Arrive.

1. Obtain slipcovers for ALL mattresses and box springs before service appointment. If these are not present at the time of treatment, treatment will not take place. Do NOT place them on the bed; our technician will do this. Covers must be made of cloth, not plastic. Must cover the entire piece of furniture and not act as a cap. The technician will ask for you to obtain new ones if the proper protection is not purchased.
2. HOARDING and massive clutter will NOT be treated that day and will be rescheduled. Getting lethal temperature through so much stuff is impossible. All clothes need to be off the floors and hung up or folded and put away — **No PILES OF CLOTHES ON THE FLOOR**. All toys are picked up and put away in toy boxes. All beds need to be clutter-free underneath. DO not move stuff into boxes and put them in the garage or sheds to be brought in after. We take bed bug eradication SERIOUSLY and the amount of money you spend to have this done seriously. If the bed frame is wood, YOU will need to take it entirely apart **the night before, not the day of,** for safety reasons and liability; we cannot do this for you. Suppose for any extenuating circumstances we need to help. In that case, you waive all liability to any damages to your belonging, residence, and injuries to yourself or others in the home if the technician believes they can help without injury to him or herself.
3. Take off all outlet covers in every bedroom, Livingroom and any room used for lounging in (NOT kitchen or bath unless infestation has moved into those rooms, usually ONLY on large outbreaks) Unless another treatment has been done before us.
4. Place all wax-based items (cosmetics, candles) and prescriptions (including OTC) next to the front door before the service appointment. (Please do not run around trying to collect all this stuff after the technician arrives!)

5. Remove any: wine, Champaign, or anything under pressure the night before into the garage or on a porch. A1 Home Pest Control will NOT be responsible for any that have become opened (uncorked, unpressurized) during the treatment or the damages that have happened due to this. It does not matter if they are opened or not, during the cooling period they will go off like little BOMBS. Also, remove any ammunition.
6. **Turn off a/c the night before** if you must have it on set it to 80 degrees or higher (you can use fans ☺) but be sure to turn it off in the morning when you get up. If not, an additional fee will be applied, because the machine will need to fight that temperature difference: costing more in fuel, more prolonged treatment time and added stress on our machine.
7. ALL occupants and animals, reptiles, birds, and fish must be out of the structure during treatment. There will be NO EXCEPTIONS! Once the A1 technician has started to set up our equipment or started any part of the chemical application, you are **NOT under any circumstances permitted back into the structure** until an A1 representative gives you the all-clear. Your health and safety are our priority!
8. The day before treatment you need to have TWO sets of clothing dried on high heat for at least an hour for each person in the home. Do not take out of drier until ready to use. The last thing you do before leaving home the day of treatment is to change into a set of those clothes. You will then change into the second set as soon as you return. All clothes you switched out of goes into the washer at each clothes change. At the end of the day, wash and dry them. This practice reduces the risk of transporting the pest and bringing them back to the home after treatment.
9. When leaving for treatment take ONLY: money, keys, phone, credit cards or wallet, LEAVE everything else behind! Do not go with huge purses, backpacks, book bags, laptop bag, blankets, pillows or anything else with you. That would include diaper bags! All these items can hold bed bugs and their eggs and will bring them back into the structure directly after treatment is done, thus keeping you infested.

Warning:

Trying to take shortcuts to any of the pre-treatment protocol items or sneak stuff out only affects you, not A1HPC. These "rules" are in place and deliberate from our expertise with bed bugs to optimize results and value to YOU. A diligent protocol **must** be followed to maintain higher eradication rates and warranty protection. Please be honest and up-front in the beginning, we are not here to judge, and A1 does not care if the bedbugs came from work or your mom's house but sourcing the origin of the infestation will reduce the risk of re-infestation. We only care that we isolate as much activity coming back in as possible, as we know having bed bugs is very stressful and expensive! A1HPC will stop treatments when any of the protocol items listed here have not been completed, depending on the circumstances. Unfortunately, you will lose your deposit, or we will charge you a trip fee. If the post protocol is not being followed or appointments are canceled (not scheduled, unit is not open to us), the warranty is then void. Believe it or not, A1HPC wants your bugs gone and will do what we can within reason on our end however this is a partnership, and we will need your help to achieve the goals you seek, ERADICATION!

Fine Print:

By signing this prep thermal treatment, the customer signing waives all claims for damages to property or person which may result indirectly from work performed by A1 Home Pest Control, Inc., except for gross negligence on the

part of A1 Home Pest control, Inc., and its affiliates. A1 Home Pest Control, Inc., is not responsible for any damages the thermal heat unit may cause such as but are not limited to; warping laminate, alcohol bottles exploding, wax melting, false wood peeling from furniture and so on. Most times these issues only happen to items made of very low quality or DIY materials.

Name (Signature): _____ Date: _____

Name (Print): _____ Date: _____

The prep list is given before the treatment, usually a couple of days in advance, so the resident understands it, has time to perform the list, and can ask any questions that might arise. This to-do list is given to all ten houses as it has pertinent information that needs to be done before treatment.

Also, in keeping with the education process, we developed and handed out flipbooks to every person who contacted us about bedbugs; however, the educated homes during this study were the only ones to receive a book. The flipbook is included here in this link below: right-click to open hyperlink

<https://drive.google.com/file/d/1GXhP9f5bOLICdDZa1xSITbhThHIRNjfk/view?usp=sharing>

The technician will arrive on the scheduled treatment day and make sure ALL the homes have completed the checklist. Things such as turning off a/c removing pertinent items (provided to the houses without the education), making sure nothing is removed from the home when the resident leaves, and a set of clothes is available in a designated area away from the infestation. After the client leaves the machine to inject, heat is started, and the air ducts are maneuvered around the unit to best suit optimal results. Once the heat machine is ready, the slipcovers are

installed on the mattresses and box springs, outlets are dusted (with Cimexa in affected rooms only), and baseboards and infected furniture are then treated with the Temprid/Cimexa mix. When each of the above steps is completed before moving on to the next, the temperatures are randomly noted to keep identifying when the unit is up to full heating. Once the unit hits the lethal threshold of 125 degrees in all infected rooms, the technician will record the treatment as having been started. These temperatures are held for a minimum of five hours, after which the technician will reassess activity levels. Some homes may take longer than the five hours due to size.

Follow up Treatments

Regardless of education and post IPM plan, a technician returned to each treated home twice in two-week intervals after the initial heat application to do another inspection and count the number of live bedbugs observed. The assessments are lengthy (over an hour), and a flashlight and 10x handheld magnifying device is used to spot younger nymphs. During the inspection, the number of nymphs and adults are recorded, and if any were alive, the technician would again retreat that area with the Temprid/Cimexa mix. On homes with more than five live bedbugs still present, we would come back in another two weeks to do another inspection.

Upon initial speaking with the client on homes with education and IPM in place, we ask where they might have picked up these arthropods from and who they have been in contact with since. These are essential questions because we try to pinpoint entry while attempting to spread them to other homes. With the client, we go over timelines of noticing the bedbugs and work

backward to understand the origin. There are some instances that a source can not be determined, and it is with great emphasis that the client knows the significance of the post IPM plan. During these conversations with the client, the bedbug biology, biting behavior, and disruption of the environment (throwing things away) are discussed in detail.

On the five homes with education and an IPM plan on the first inspection after treatment, the technician would ensure that the client was doing the outlined items to keep re-infestation low or nonexistent. Each IPM plan would be tailored to the individual home's needs and risk levels associated with the residents. If the residents are not following the IPM plan, we again go over its importance and remind them that they do not want to go through this process again and ask if there is any way to help facilitate the plan being put into place. Usually, it is just a matter of the client altering their daily routine and remembering to keep fresh clothes out in a secluded area of the home to change into before actually entering the dwelling. By changing clothes and having the client put them immediately in the dryer, we can control what is coming through the threshold that may be picked up on the person while away from the residence. Some clients will change in their garages or porches and use as a portable heat treatment container called The Ranger (<https://thermalstrike.com/>) to put the contaminated clothes, luggage, purses, and the like into eliminating any bedbug's ability to reenter the home. The client must strip down completely naked since the bedbugs could be on socks, underwear, and bras and change into freshly laundered clothes they have left out in a sealed bag. Any purses, backpacks, luggage, or items of that nature will not enter the home.

In homes with no education, the basic protocols are performed, and slipcovers are still required. Although no education is said to occur, these homes mainly do not have an IPM plan for re-infestations. There can be several reasons a home that is treated did not receive the proper

education or IPM plan. The cause of minor to no education is mostly on vacation homes, people renting and not paying for the service, part-time residents, or very elderly clients who may not understand what is relayed to them. Then, of course, two follow-up inspections two weeks later, and active bedbugs are seen recorded with higher numbers inducing a third inspection/treatment. These homes are still treated the same way as those that have been educated with heat and chemicals applied explicitly to specific areas, as stated above.

Results

All the homes using the education/IPM process were noted along with the severity of the infestation, risk factors, activity at first follow up, activity at second follow up, and whether adults or nymphs were observed. The data was collected over thirty days. The initial treatment is counted as day one, and every two weeks, a follow-up treatment/inspection is documented (two follow-ups that are two weeks apart). After the second follow-up, homes that still have activity would receive one last follow-up (the third follow-up extending into 45 days) with a strong warning that the infestation will continue without correct guidance. This experiment gave us an idea of how education and IPM play a critical component in eradicating bedbugs. If more adults are observed than nymphs, it is a general indication that the post protocols are not being followed which allowed reentry of bedbugs into the residence. Our data shows that homes with the IPM plans had a far lower number or no bedbugs found on the first follow-up than homes without a plan. The results also noted no bedbugs found in the homes with prior bedbug education on the second follow-up. However, three out of five houses with no education still had activity and needed another treatment (see excel spreadsheet below fig 2). In order to achieve a much higher eradication rate, those who are treating for these arthropods must educate the client. The infestation remaining is relatively high when the client is not adequately

educated and included in the IPM plan. The treatments of bedbugs have to be a partnership with shared knowledge a solid treatment foundation.

Client/Initial	Educ. & IPM plan	Risk Factor	Initial Severity	Follow-Up One	Additional Follow up	Average on Follow-Up
Client One	NO	moderate	light	2	0 adults	2.9
Client Two	Yes	Low	Moderate	1	0 adult	
Client Three	yes	Low	light	0	0	
Client Four	NO	Low	Moderate	5	1 adults	
Client Five	Yes	low	Moderate	0	0	
Client Six	NO	low	Moderate	0	0	
Client Seven	yes	HIGH	Moderate	1	0 adult	
Client Eight	NO	Moderate	Light	3	1 all juveniles	
Client Nine	NO	moderate	Moderate	10	15 Adults	
Client Ten	Yes	Moderate	Moderate	7	1 Juvenile	

Fig. 2 – Data collected from ten homes with heat treatments performed. The names highlighted in pink are the treatments with NO education or IPM plan.

Discussion

After the experiment of the ten homes with and without education and an IPM plan, we can see that the results favor having these two main core principles at the heart of every bedbug treatment. Without knowing the bedbug biology and what to do to keep them from reentering the residence, the homes will continue to have ongoing issues with infestations. Not only is the pest problem not resolved, but the continued use of chemicals in a living space is not healthy nor advised. We will not go past three follow-ups due to chemicals and health concerns with over-exposure and resistance. It is not recommended to continue using chemicals against bedbugs to avoid building resistance within a population. There are only so many different modes of action

on bedbugs in chemical form, and with the increased usage, they will soon become resistant to those. There must be accountability and knowledge of these pests to reduce chemical exposure and keep the possibility of resistance low. Throughout this experiment, all that has been used or done has been years of trial and error with treating bed bugs, not from a book or online source. We have used large colonies of bedbugs to gain knowledge of their behavior and reproduction. Here is a picture of the feeding process fig.3:



Fig. 3 Bedbug is feeding on a human donor. Photo credit A1 Home Pest Control

There was also a learning curve (in real life) of doing inspections, what to look for, and the best methods to assess without wasting time looking through items that bedbugs would not harbor. For example, here is a picture of bedbug eggs during an inspection in figure 4 within a couch cushion:



Fig. 4 eggs magnified by 25x and zoomed in the picture with a stage one nymph. Photo Credit A1 Home Pest Control

You would not look through cabinets in the kitchen for these insects because they have nothing to survive on in this area unless the infestation is so extreme the carry capacity has pushed them far from nesting sites. However, couches, upholstered chairs, beds, and places that people frequently sit or lay down for lengths at a time are the best inspections areas. Another tip is to use BedBug dots or bed buggies to help monitor the size of an infestation before treatment even begins. When the monitoring begins, have the client use white or pastel-colored sheets to see any new bloodstains that could help indicate activity. As this process we used has developed over the year, we use some other tricks. They are moving any furniture at least an inch away from the walls in the affected room. By moving furniture away from walls, Bedbugs have to work harder to feed on you. Also, putting Vaseline on the bed's legs from the floor to halfway up

will snag any wandering up the frame. These are all things all of us can implement that work and avoid the use of chemicals. Will it get rid of an infestation, maybe a tiny one, but at least it a good start at monitoring and possible control.

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